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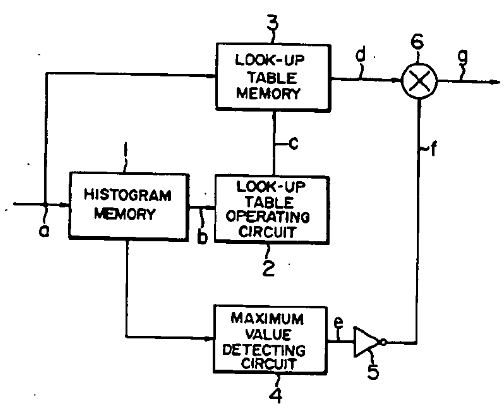
(54) Intensity correction device.

(57) The invention relates to an intensity correction device for automatically adjusting an intensity of an input video signal to an optical image by detecting characteristics of the input image, and intends to provide intensity correction with maintaining clear image by reducing magnitude of correction or by not effecting correction when the luminance level of the input luminance signal is concentrated to a certain luminance level. The intensity correction device includes a histogram memory (1), a look-up table operating circuit (2), a look-up table (3), a maximum value detecting circuit (4), and an invertor (5) and a multiplier (6), limiter (7), or a gain control circuit. By this, when the luminance level of the input video signal is concentrated to the certain luminance level, magnitude of correction can be reduced or made zero. Therefore, by detecting the characteristics of the input image, the intensity of the input video signal can be automatically corrected to the optimal image for providing better picture quality.

FIG. 1



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BACKGROUND OF THE INVENTION

The present invention relates to an intensity correction device for detecting feature of an input image and automatically adjusting intensity of a video signal from a television receiver, a video tape recorder, a video projector or so forth for obtaining an optimal image.

In the recent years, there is a tendency for requiring higher picture quality for television receivers. For this, an intensity correction device which can automatically obtain an optimal intensity with detecting feature of an input image has been given higher importance.

Discussion for the conventional intensity correction device will be given herebelow with reference to Figs. 8 and 9. Fig. 8 shows the construction of the conventional intensity correction device. In Fig. 8, the reference numeral 1 denotes a histogram memory for obtaining luminance distribution of an input luminance signal, 2 denotes a look-up table operating circuit for performing cumulation of a histogram and normalizing respective data so that the maximum cumulative frequency become coincident with a maximum value of an output luminance signal, 3 denotes a look-up table memory for storing the data normalized by the look-up table operating circuit 2 and permitting reading out of a correction signal corresponding to a luminance level of the input signal.

Operation of the intensity correction device constructed set forth above will be discussed herebelow with reference to Fig. 9.

Fig. 9 is a graph illustrating manner of luminance conversion in the prior art.

At first. histogram is established by dividing input luminance level into an appropriate numbers. Then, the luminance distribution of the input luminance signal a, as illustrated in Fig. 9A, is stored in the histogram memory 1. The contents of this memory 1 is periodically cleared to set respective data zero. The interval for clearing the data in the memory 1 is typically selected in a period corresponding to a vertical scanning period or multiple thereof. Next, the look-up table operating circuit 2 cumulates the data of the histogram, calculates a normalizing coefficient so that the maximum cumulative frequency can be the maximum value of the output luminance level, and multiplies respective data of the histogram by the coefficient thus derived. The results are stored in the look-up table memory 3. These manners are illustrated in Figs. 9B and 9C. The look-up table memory 3 outputs a difference between the data corresponding to a luminance level of the input signal a and the luminance level as a correction signal d as shown in Fig. 9D. With this correction signal d, intensity correction is performed.

However, in the construction set forth above, when the input luminance signal is concentrated at a certain luminance level, the level is corrected in excessive manner as illustrated in Figs. 9E to 9H. In case of dynamic image of the television, this makes the corrected image far different from the actual image to rather degrade picture quality.

SUMMARY OF THE INVENTION

In view of the drawback in the prior art as set forth above, it is an object of the present invention to provide an intensity correction device which reduces degree of correction or makes correction zero when an input luminance signal is concentrated at a certain luminance level.

In order to accomplish the above-mentioned object. an intensity correction device, according to the first aspect of the invention, comprises:

a histogram memory for forming histogram of an input luminance signal;

a look-up table operating circuit for cumulating the histogram and normalizing so that the maximum cumulative frequency becomes the maximum value of an output luminance signal;

a look-up table memory for storing the normalized data and outputting a correction signal;

a maximum value detecting circuit for detecting the maximum value of the histogram; and

a multiplier for multiplying an inverse value of the maximum value and the correction signal.

Also, an intensity correction device, according to the second aspect of the invention, comprises:

a histogram memory for forming histogram of an input luminance signal;

a look-up table operating circuit for cumulating the histogram and normalizing so that the maximum cumulative frequency becomes the maximum value of an output luminance signal;

a look-up table memory for storing the normalized data and outputting a correction signal;

a maximum value detecting circuit for detecting a maximum value of differences of the normalized data; and

a multiplier for multiplying an inverse value of the maximum value and the correction signal.

Furthermore, an intensity correction device, according to the third aspect of the invention, comprises:

a histogram memory for forming histogram of an input luminance signal;

a look-up table operating circuit for cumulating the histogram and normalizing so that the maximum cumulative frequency becomes the maximum value of an output luminance signal;

a look-up table memory for storing the normalized data and outputting a correction signal;

a maximum value detecting circuit for detecting a maximum value of differences of the normalized data; and

a limiter for setting the correction signal to zero when the maximum value exceeds a predetermined value.

In addition, an intensity correction device, according to the fourth aspect of the invention, comprises:

a histogram memory for forming histogram of an input luminance signal;

a look-up table operating circuit for cumulating the histogram and normalizing so that the maximum cumulative frequency becomes the maximum value of an output luminance signal;

a look-up table memory for storing the normalized data and outputting a correction signal;

a maximum value detecting circuit for detecting a maximum value of differences of the normalized data; and

a gain control circuit for varying gain of the correction signal depending upon the maximum value.

With the above-mentioned first aspect of the invention, by obtaining the histogram, detecting the maximum value of the data of the obtained histogram, and multiplying the inverse value of the maximum value and the correction signal, the magnitude of correction can be reduced when the luminance level of the input luminance signal is concentrated to the certain luminance level.

With the second aspect of the invention, by obtaining the histogram of the input luminance signal, cumulating the obtained histogram, normalizing so that the maximum cumulative frequency becomes the maximum value of the output luminance signal, detecting the maximum value of the difference of the normalized data and multiplying the inverse value of the maximum value and the correction signal, the magnitude of correction can be reduced when the luminance level of the input luminance signal is concentrated to the certain luminance level.

With the third aspect of the invention, by obtaining the histogram of the input luminance signal, cumulating the obtained histogram, normalizing so that the maximum cumulative frequency becomes the maximum value of the output luminance signal, detecting the maximum value of the difference of the normalized data and making the correction signal to zero when the maximum value exceeds a predetermined value, the correction can be made zero when the input luminance signal is concentrated to the certain luminance level.

With the fourth aspect of the invention, by obtaining the histogram of the input luminance signal, cumulating the obtained histogram, normalizing so that the maximum cumulative frequency becomes the maximum value of the output luminance signal, detecting the maximum value of the difference of the normalized data and varying the gain of the correction signal depending upon the maximum value, the magnitude of correction can be reduced when the input luminance signal is concentrated to the certain luminance level.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of the first embodiment of an intensity correction device according to the present invention;

Fig. 2 is a graph for illustrating operation of the shown embodiment of the intensity correction device;

Fig. 3 is a block diagram of the second embodiment of an intensity correction device according to the present invention;

Fig. 4 is a graph for illustrating operation of the second embodiment of the intensity correction device;

Fig. 5 is a block diagram of the third embodiment of an intensity correction device according to the present invention;

Fig. 6 is a block diagram of the fourth embodiment of an intensity correction device according to the present invention;

Fig. 7 is a graph showing a relationship between a maximum value and an intensity-correction signal;

Fig. 8 is a block diagram of the conventional intensity correction device; and

Fig. 9 is a graph for illustrating operation of the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The referred embodiments of the present invention will be discussed herebelow with reference to the accompanying drawings.

Fig. 1 is a block diagram showing the first embodiment of an intensity correction device according to the present invention. In Fig. 1, the reference numeral 1 denotes a histogram for detecting luminance distribution of an input luminance signal. The reference numeral 2 denotes a look-up table operating circuit 2 for cumulating the histogram and normalizing respective data so that the maximum cumulative frequency becomes the maximum value of an output luminance signal, 3 denotes a look-up table memory for storing the data normalized by the look-up table operating circuit 2 and permitting reading out of a correction signal corresponding to the luminance level of the input signal. The reference numeral 4 denotes a maximum value detecting circuit for detecting a maximum value of the data of the histogram obtained at the histogram memory 1. The reference numeral 5 denotes an invertor for obtaining an inverse value of the maximum value obtained at the maximum value detecting circuit 4. The reference numeral 6 denotes a multiplier for multiplying the inverse value of the maximum value obtained through the invertor 5 by the correction signal read out from the look-up table memory 3.

Operation of the first embodiment of the intensity correction device constructed as set forth above will be discussed with reference to Fig. 2. Fig. 2 shows manner of luminance conversion.

At first, the histogram is established by dividing the input luminance level into an appropriate numbers. Then, the luminance distribution of the input luminance signal a as illustrated in Fig. 2A is stored in the histogram memory 1. The content of the memory 1 is periodically cleared so as to set respective data zero. This period is typically selected at a period corresponding to one vertical scanning period or the multiple thereof. Then, the look-up table operating circuit 2 cumulates the histogram, calculates a normalization coefficient so that the maximum cumulative frequency becomes the maximum value of the output luminance level, and multiplies respective data of the histogram by the coefficient thus derived. The results are stored in the look-up table memory 3. The manners of this process are shown in Figs. 2B and 2C. The look-up table memory 3 outputs a difference between the data corresponding to a luminance level of the input signal a and the luminance level as a correction signal d. On the other hand, the maximum value detecting circuit 4 detects the maximum value e of the data obtained at the histogram memory 1. Then, in the invertor 5, an inverse value f of the maximum value e is derived. The multiplier 6 multiplies the inverse value f of the maximum value e by the correction signal d. Through these process, the intensity correction signal g as illustrated in Fig. 2D can be derived so that intensity correction can be performed with this intensity correction signal g.

According to the shown embodiment as set forth above, when the luminance level of the input signal is concentrated to a certain luminance level, since the maximum value e becomes large, the intensity correction signal g becomes small as shown in Figs. 2E to 2H. As a result, the magnitude of intensity correction can be made smaller.

The second embodiment of an intensity correction device according to the present invention will be discussed herebelow with reference to the drawings.

Fig. 3 is a block diagram showing the second embodiment of the intensity correction device according to the present invention. In Fig. 3, the reference numeral 1 denotes a histogram for detecting luminance distribution of an input luminance signal. The reference numeral 2 denotes a look-up table operating circuit 2 for cumulating the histogram and normalizing respective data so that the maximum cumulative frequency becomes the maximum value of an output luminance signal, 3 denotes a look-up table memory for storing the data normalized by the look-up table operating circuit 2 and permitting reading out of a correction signal corresponding to the luminance level of the input signal. The reference numeral 4 denotes a maximum value detecting circuit for detecting a maximum value of the normalized of the histogram obtained at the histogram memory 1. The reference numeral 5 denotes an invertor for obtaining an inverse value of the maximum value obtained at the maximum value detecting circuit 4. The reference numeral 6 denotes a multiplier for multiplying the inverse value of the maximum value obtained through the invertor 5 by the correction signal read out from the look-up table memory 3.

Operation of the second embodiment of the intensity correction device constructed as set forth above will be discussed with reference to Figs. 2, 4 and 7. Fig. 2 shows manner of luminance conversion.

At first, the histogram is established by dividing the input luminance level into an appropriate numbers. Then, the luminance distribution of the input luminance signal a as illustrated in Fig. 2A is stored in the histogram memory 1. The content of the memory 1 is periodically cleared so as to set respective data zero. This period is typically selected at a period corresponding to one vertical scanning period or the multiple thereof. Then, the look-up table operating circuit 2 cumulates the histogram, calculates a normalization coefficient so that the maximum cumulative frequency becomes the maximum value of the output luminance level, and multiplies respective data of the histogram by the coefficient thus derived. The results are stored in the look-up table memory 3. The manners of this process are shown in Figs. 2B and 2C. The look-up table memory 3 outputs a difference between the data corresponding to a luminance level of the input signal a and the luminance level as a correction signal d. On the other hand, the maximum value detecting circuit 4 detects the maximum value h of the difference of data obtained at the look-up table operating circuit 2. Then, in the invertor 5, an inverse value f of the maximum value h is derived. The multiplier 6 multiplies the inverse value f of the maximum value e by the correction signal d. Through these process, the intensity correction signal g as illustrated in Fig. 4B can be derived so that intensity correction can be performed with this intensity correction signal g.

According to the second embodiment as set forth above, when the luminance level of the input signal is concentrated to a certain luminance level, since the maximum value h becomes large, the intensity correction signal g becomes small as shown in Figs. 4C and 4D. The relationship between the maximum value h and the intensity correction signal g is illustrated in Fig. 7A. As can be appreciated, the shown embodiment is differentiated from the first embodiment, in that the maximum value of the difference of the normalized data is detected. Therefore, the upper limit of the maximum value of the difference is constant irrespective of the values of overall histogram. As a result, the intensity correction signal g corresponding to the luminance distribution can be easily obtained. Also, when the luminance level is concentrated, the magni-

tude of intensity correction can be made smaller.

The third embodiment of the intensity correction device according to the present invention will be discussed herebelow with reference to the drawings.

Fig. 5 is a block diagram showing the third embodiment of the intensity correction device according to the present invention. In Fig. 5, the reference numeral 1 denotes a histogram for detecting luminance distribution of an input luminance signal. The reference numeral 2 denotes a look-up table operating circuit 2 for cumulating the histogram and normalizing respective data so that the maximum cumulative frequency becomes the maximum value of an output luminance signal, 3 denotes a look-up table memory for storing the data normalized by the look-up table operating circuit 2 and permitting reading out of a correction signal corresponding to the luminance level of the input signal. The reference numeral 4 denotes a maximum value detecting circuit for detecting a maximum value of the normalized of the histogram obtained at the histogram memory 1. The reference numeral 5 denotes an invertor for obtaining an inverse value of the maximum value obtained at the maximum value detecting circuit 4. The reference numeral 7 denotes a limiter for setting the correction signal to zero when the maximum value obtained by the maximum value detecting circuit 4 exceeds a given value.

Operation of the third embodiment of the intensity correction device constructed as set forth above will be discussed with reference to Figs. 2, 4 and 7. Fig. 2 shows manner of luminance conversion.

At first, the histogram is established by dividing the input luminance level into an appropriate numbers. Then, the luminance distribution of the input luminance signal a as illustrated in Fig. 2A is stored in the histogram memory 1. The content of the memory 1 is periodically cleared so as to set respective data zero. This period is typically selected at a period corresponding to one vertical scanning period or the multiple thereof. Then, the look-up table operating circuit 2 cumulates the histogram, calculates a normalization coefficient so that the maximum cumulative frequency becomes the maximum value of the output luminance level, and multiplies respective data of the histogram by the coefficient thus derived. The results are stored in the look-up table memory 3. The manners of this process are shown in Figs. 2B and 2C. The look-up table memory 3 outputs a difference between the data corresponding to a luminance level of the input signal a and the luminance level as a correction signal d. On the other hand, the maximum value detecting circuit 4 detects the maximum value h of the difference of data obtained at the look-up table operating circuit 2. Then, by the litter 7. when the maximum value h exceeds the given value, the intensity correction signal g which makes the correction signal d zero, is obtained.

With the third embodiment of the intensity correction device according to the present invention, when the input luminance signal is concentrated at a certain luminance level, the maximum value h is increased to exceed the given value. Then, the intensity correction signal g becomes zero. The relationship between the maximum value h and the intensity correction signal g is illustrated in Fig. 7B. Conversely to the foregoing second embodiment, the shown embodiment of the intensity correction device do not effect intensity correction when the maximum value h exceeds the given value.

The fourth embodiment of the intensity correction device according to the present invention will be discussed herebelow with reference to the drawings.

Fig. 6 is a block diagram showing the fourth embodiment of the intensity correction device according to the present invention. In Fig. 6, the reference numeral 1 denotes a histogram for detecting luminance distribution of an input luminance signal. The reference numeral 2 denotes a look-up table operating circuit 2 for cumulating the histogram and normalizing respective data so that the maximum cumulative frequency becomes the maximum value of an output luminance signal, 3 denotes a look-up table memory for storing the data normalized by the look-up table operating circuit 2 and permitting reading out of a correction signal corresponding to the luminance level of the input signal. The reference numeral 4 denotes a maximum value detecting circuit for detecting a maximum value of the normalized of the histogram obtained at the histogram memory 1. The reference numeral 5 denotes an invertor for obtaining an inverse value of the maximum value obtained at the maximum value detecting circuit 4. The reference numeral 8 denotes a gain control circuit for varying gain of the correction signal d depending upon the maximum value obtained at the maximum value detecting circuit 4.

Operation of the fourth embodiment of the intensity correction device constructed as set forth above will be discussed with reference to Figs. 2, 4 and 7. Fig. 2 shows manner of luminance conversion.

At first, the histogram is established by dividing the input luminance level into an appropriate numbers. Then, the luminance distribution of the input luminance signal a as illustrated in Fig. 2A is stored in the histogram memory 1. The content of the memory 1 is periodically cleared so as to set respective data zero. This period is typically selected at a period corresponding to one vertical scanning period or the multiple thereof. Then, the look-up table operating circuit 2 cumulates the histogram, calculates a normalization coefficient so that the maximum cumulative frequency becomes the maximum value of the output luminance level, and multiplies respective data of the histogram by the coefficient thus derived. The results are stored in the look-up table memory 3. The manners of this process are shown in Figs. 2B and 2C. The look-up table memory 3 outputs a difference between

the data corresponding to a luminance level of the input signal a and the luminance level as a correction signal d. On the other hand, the maximum value detecting circuit 4 detects the maximum value h of the difference of data obtained at the look-up table operating circuit 2. Then, by the gain control circuit 8, the intensity correction signal g varying the gain of the correction signal d depending upon the maximum value h is obtained. The intensity correction is thus performed with this intensity correction signal g.

With the fourth embodiment as set forth above, when the input luminance signal is concentrated at the certain luminance level, the maximum value h becomes larger. In such case, the gain of the correction signal d is controlled by the gain control circuit 8 so as to make the intensity correction signal g smaller. One example of the relationship between the maximum value h and the intensity correction signal g is illustrated in Fig. 7C. Different from the foregoing third embodiment of the intensity correction device, the shown embodiment performs smooth variation of the gain so that intensity correction can be done without causing noticeable variation of intensity.

It should be noted that, although the all of the shown embodiment employ the histogram memory 1, the histogram memory can be a cumulative histogram which derives cumulative histogram. In such case, the cumulative function of the look-up table operating circuit 2 can be neglected.

Claims

1. An intensity correction device comprising:
   a histogram memory (1) for forming histogram of an input luminance signal;
   a look-up table operating circuit (2) for cumulating the histogram and normalizing so that the maximum cumulative frequency becomes the maximum value of an output luminance signal;
   a look-up table memory (3) for storing the normalized data and outputting a correction signal;
   a maximum value detecting circuit (4) for detecting the maximum value of the histogram; and
   a multiplier (6) for multiplying an inverse value of the maximum value and the correction signal.

2. An intensity correction device comprising:
   a histogram memory (1) for forming histogram of an input luminance signal;
   a look-up table operating circuit (2) for cumulating the histogram and normalizing so that the maximum cumulative frequency becomes the maximum value of an output luminance signal;
   a look-up table memory (3) for storing the normalized data and outputting a correction signal;
   a maximum value detecting circuit (4) for detecting a maximum value of differences of the normalized data; and
   a multiplier (6) for multiplying an inverse value of the maximum value and the correction signal.

3. An intensity correction device comprising:
   a histogram memory (1) for forming histogram of an input luminance signal;
   a look-up table operating circuit (2) for cumulating the histogram and normalizing so that the maximum cumulative frequency becomes the maximum value of an output luminance signal;
   a look-up table memory (3) for storing the normalized data and outputting a correction signal;
   a maximum value detecting circuit (4) for detecting a maximum value of differences of the normalized data; and
   a limiter (7) for setting the correction signal to zero when said maximum value exceeds a predetermined value.

4. An intensity correction device comprising:
   a histogram memory (1) for forming histogram of an input luminance signal;
   a look-up table operating circuit (2) for cumulating the histogram and normalizing so that the maximum cumulative frequency becomes the maximum value of an output luminance signal;
   a look-up table memory (3) for storing the normalized data and outputting a correction signal;
   a maximum value detecting circuit (4) for detecting a maximum value of differences of the normalized data; and
   a gain control circuit (8) for varying gain of said correction signal depending upon said maximum value.

FIG. 1

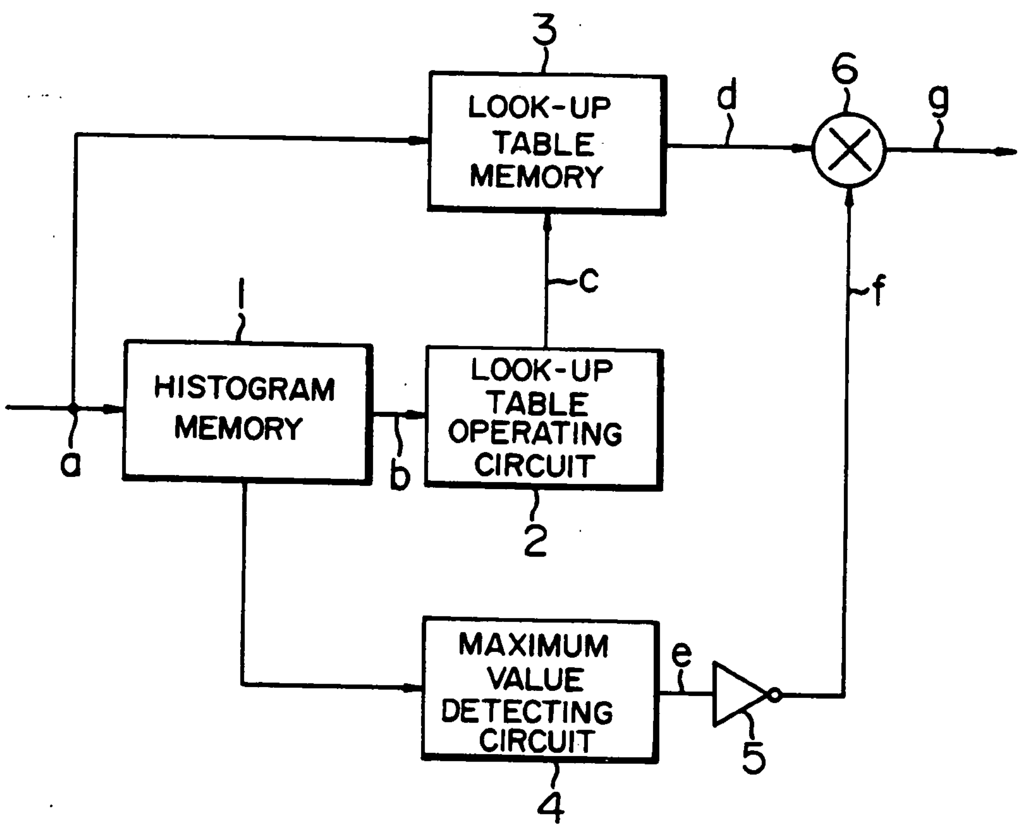

3
LOOK-UP TABLE MEMORY
d
6
g
c
f
1
HISTOGRAM MEMORY
LOOK-UP TABLE OPERATING CIRCUIT
a
b
2
MAXIMUM VALUE DETECTING CIRCUIT
e
5
4

FIG. 2A

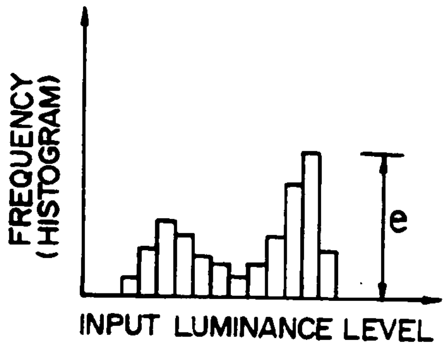


FIG. 2B

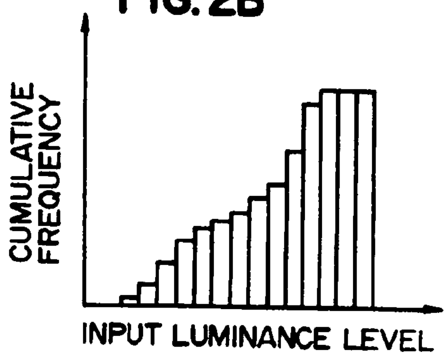


FIG. 2C

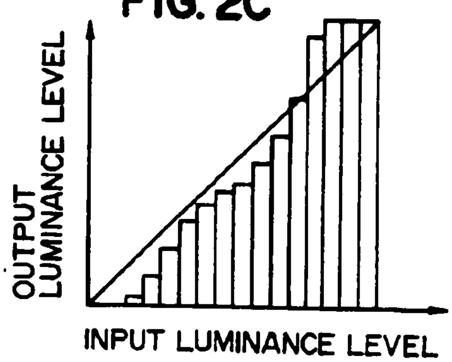


FIG. 2D

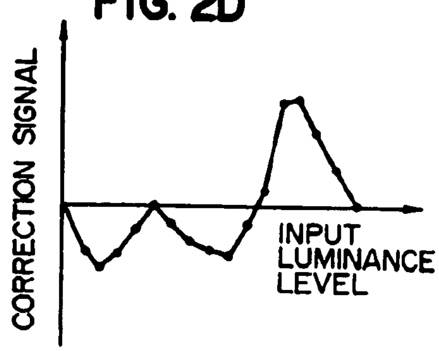


FIG. 2E

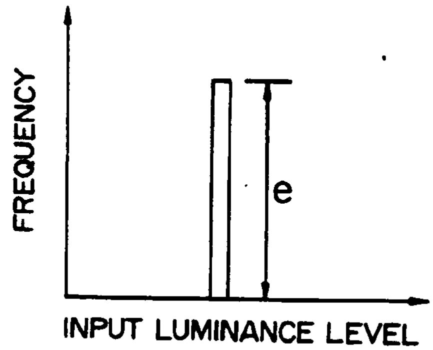


FIG. 2F

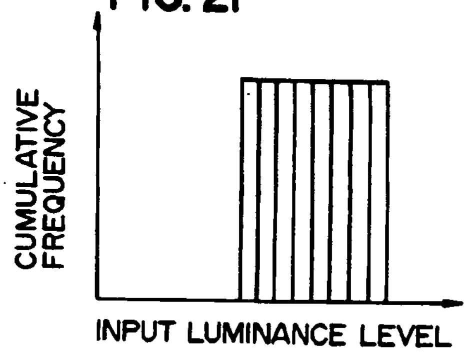


FIG. 2G

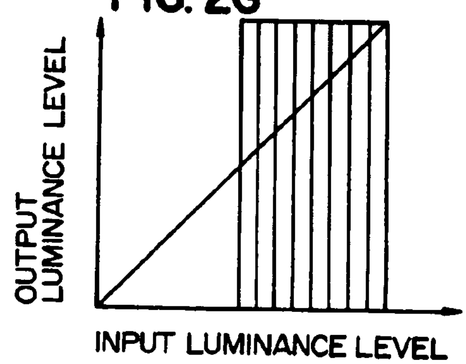


FIG. 2H

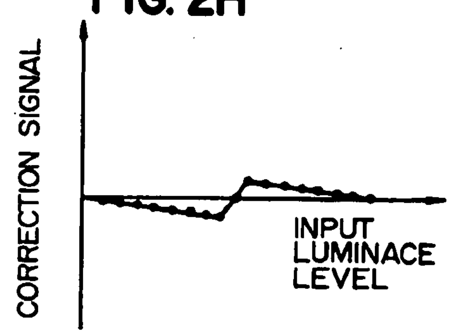
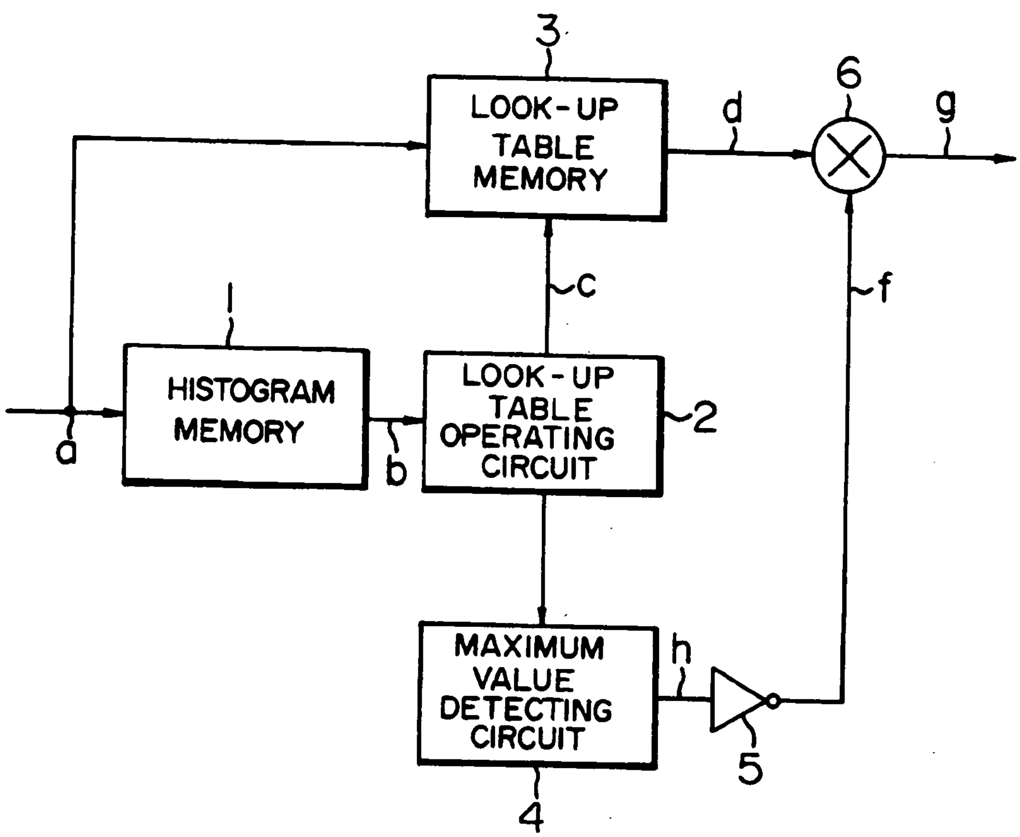


FIG. 3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d
6
g
c
f
1
HISTOGRAM MEMORY
a
b
LOOK-UP TABLE OPERATING CIRCUIT
2
MAXIMUM VALUE DETECTING CIRCUIT
h
5
4

FIG. 4A

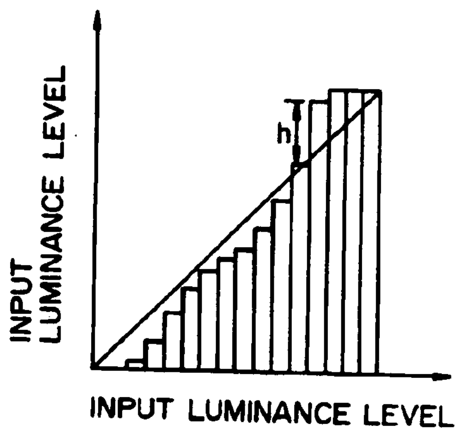


FIG. 4C

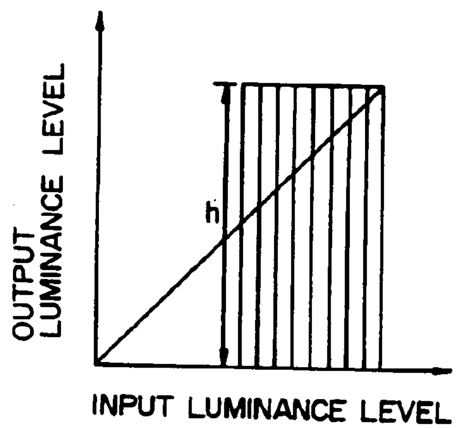


FIG. 4B

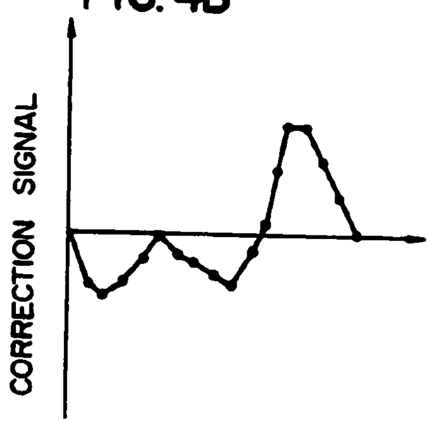


FIG. 4D

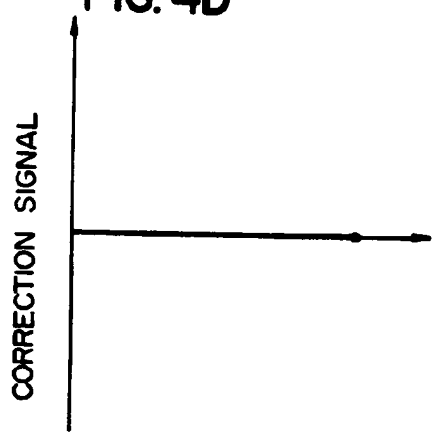
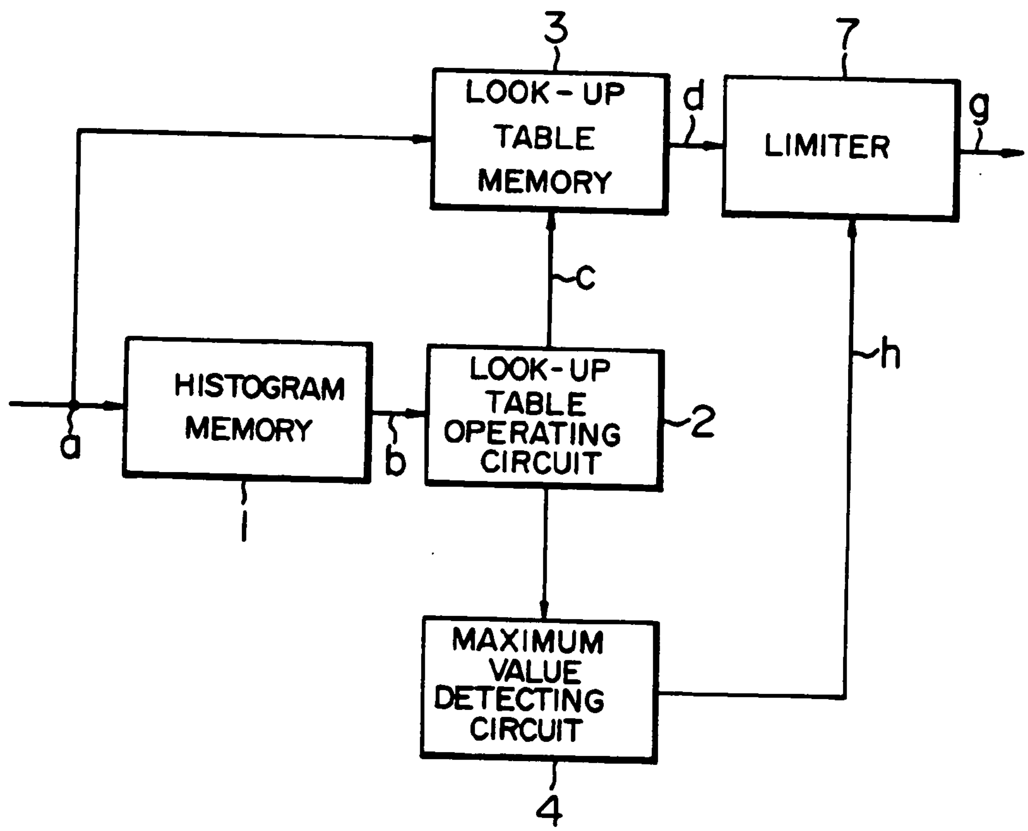


FIG. 5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7
LIMITER
d
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LOOK-UP TABLE OPERATING CIRCUIT
2
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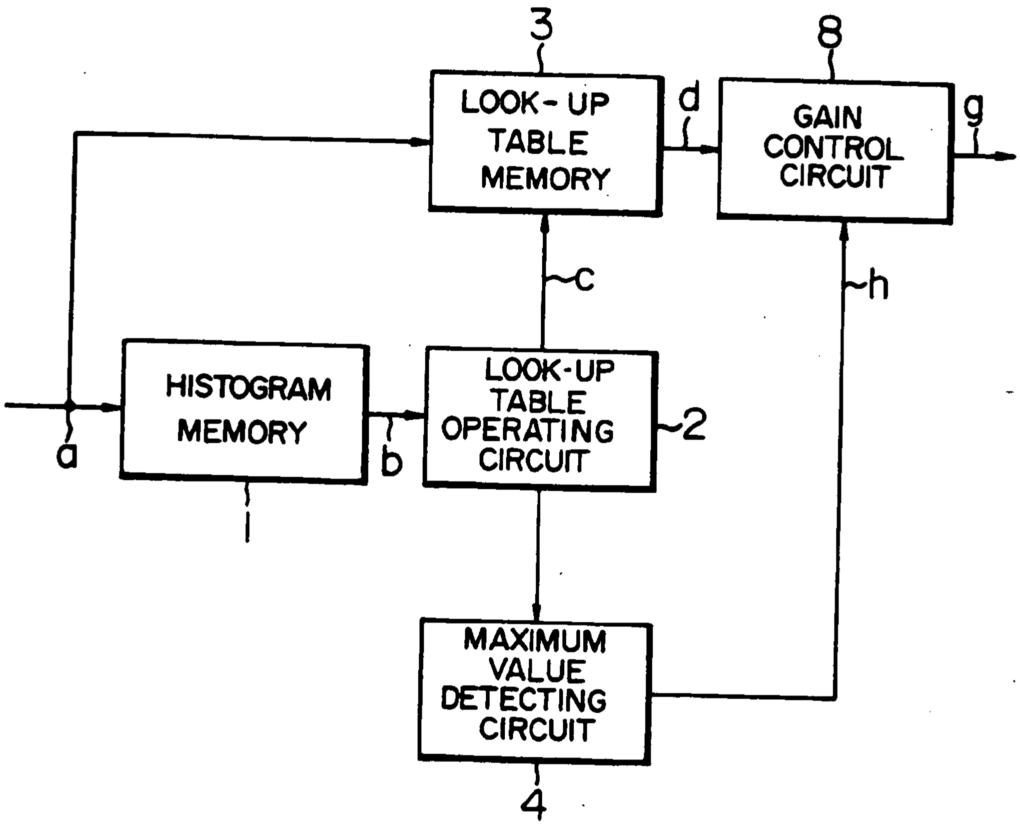
b
1
MAXIMUM VALUE DETECTING CIRCUIT
4

F I G. 6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8
LOOK-UP TABLE MEMORY
d
GAIN CONTROL CIRCUIT
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c
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HISTOGRAM MEMORY
LOOK-UP TABLE OPERATING CIRCUIT
2
a
b
1
MAXIMUM VALUE DETECTING CIRCUIT
4

FIG. 7A

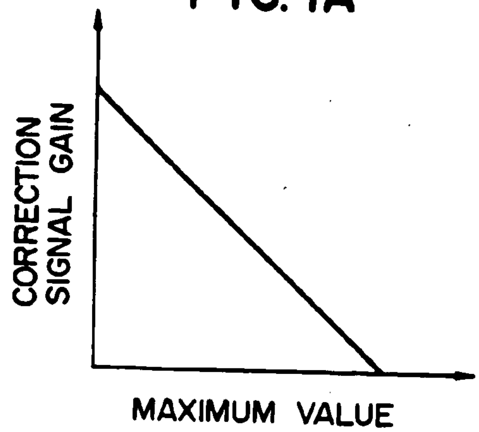

FIG. 7B

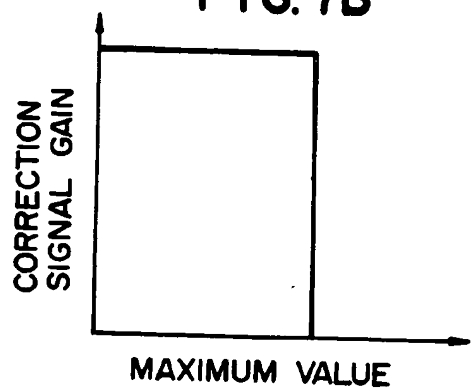

FIG. 7C

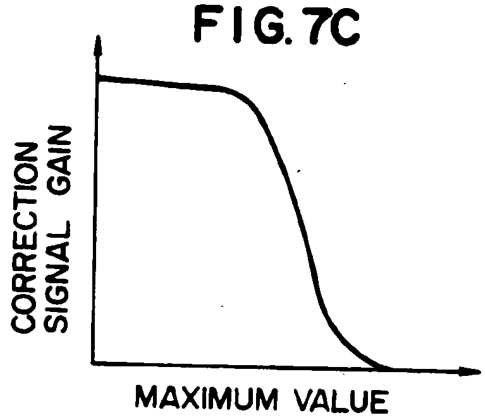

FIG. 8

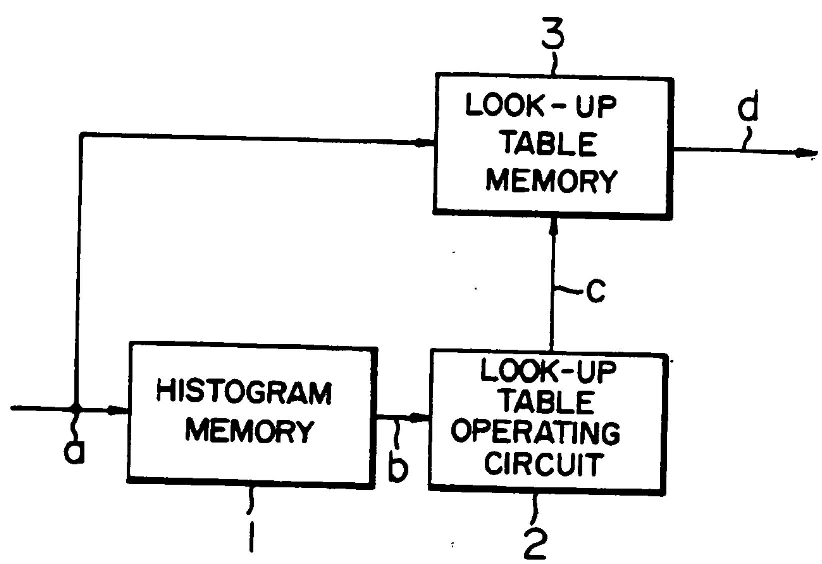
3
LOOK-UP TABLE MEMORY
d
c
HISTOGRAM MEMORY
LOOK-UP TABLE OPERATING CIRCUIT
a
b
1
2

FIG. 9A

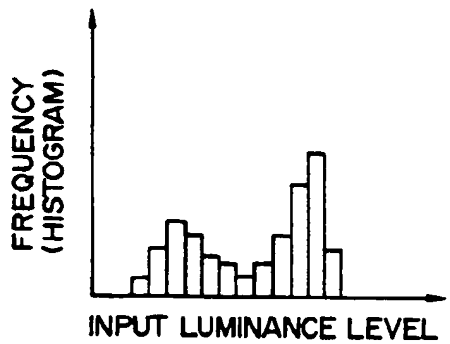

FIG. 9E

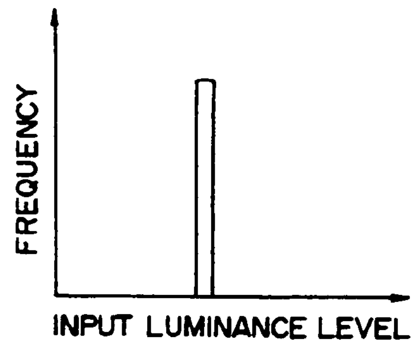

FIG. 9B

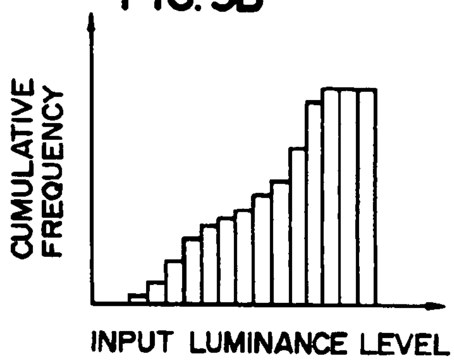

FIG. 9F

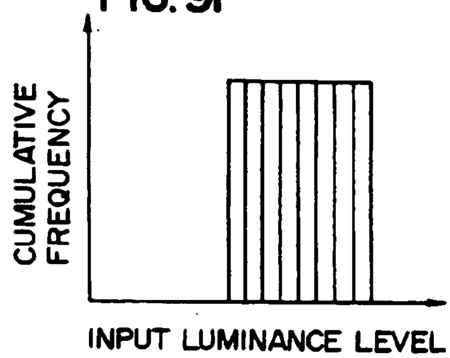

FIG. 9C

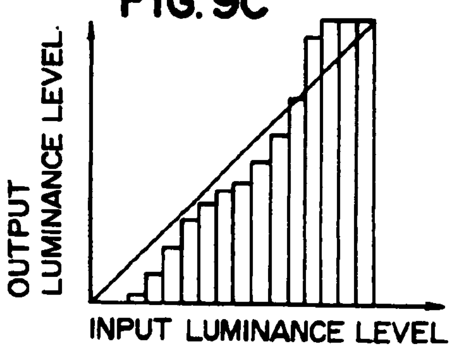

FIG. 9G

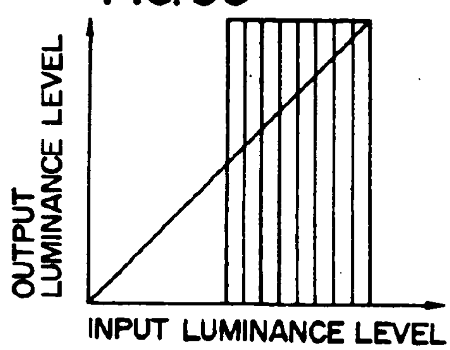

FIG. 9D

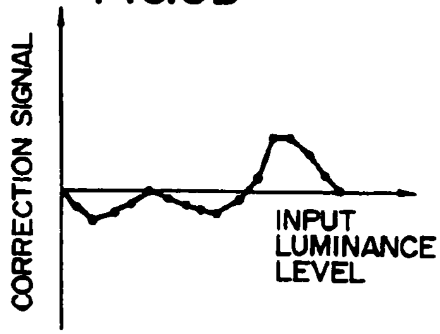

FIG. 9H